International Journal of Public Health Excellence (IJPHE)
Vol. 5, Issue 2, January-May 2026, pp. 139~147
Journal Homepage: https://ejournal.ipinternasional.com/index.php/ijphe
ISSN: 2809-9826, DOI: 10.55299/ijphe.v5i2.1522

Eccentric Exercise Intervention is Better Than Active Static Stretching for Increasing Hamstring Muscle Flexibility and Agility in Futsal Players at Bali Bulldogs Football Club

Amarilis Brensiline Sekar Kinasih[1], Indira Vidiari Juhanna[2], Syahmirza Indra Lesmana[3]
[1]Master of Sport Physiology, Faculty of Medicine, Universitas Udayana, 80234, Denpasar, Indonesia.
[2]Department of Physiology, Faculty of Medicine, Universitas Udayana, 80234, Denpasar, Indonesia.
[3]Faculty of Physiotherapy, Universitas Esa Unggul, Jakarta, Indonesia.

Article Info

Article history:

Received March 18, 2026
Revised April 15, 2026
Accepted May 08, 2026

Corresponding Author:

Amarilis Brensiline Sekar Kinasih
Master of Sport Physiology, Faculty of Medicine, Universitas Udayana, 80234, Denpasar, Indonesia
Email: amarilisekar7@gmail.com

ABSTRACT

Futsal requires high hamstring flexibility and agility for peak performance and injury prevention. Players often face muscle shortening and reduced agility, which can negatively impact their game. Active static stretching is a common method for improving flexibility, but eccentric exercise holds significant promise for increasing muscle length and strength, which are vital for both preventing muscle shortening and boosting agility. This study aimed to compare the effectiveness of these two scientifically-backed interventions, as direct comparisons in futsal players are limited. Using a quasi-experimental pre-test and post-test design, 22 male futsal players (aged 18-25) were divided into two groups: one for active static stretching and one for eccentric exercise. The interventions were performed three times a week for six weeks. Flexibility was assessed with the Active Knee Extension Test (AKET), while agility was measured using the Illinois Agility Test. The data were analyzed using paired simple t-tests and independent t-tests. The results showed that both interventions improved flexibility and agility ($p<0.05$). However, eccentric exercise was significantly more effective. The eccentric exercise group showed a greater increase in flexibility (mean difference: -3.409 ± 1.0521) compared to the active static stretching group (mean difference: -0.482 ± 0.1722), with a p-value of 0.000. Similarly, agility improved more in the eccentric exercise group (mean difference: -1.127 ± 0.4452) than in the active static stretching group (mean difference: -0.282 ± 0.1168), also with a p-value of 0.000. In conclusion, eccentric exercise is more effective than active static stretching for enhancing hamstring flexibility and agility in futsal players, making it a highly recommended addition to training programs.

Keywords: Active Static Stretching, Eccentric Exercise, Hamstring Flexibility, Agility, Futsal Players

1. INTRODUCTION

Futsal is an indoor football game that requires players to have high flexibility and agility to adapt to the fast and intense dynamics of the game. Hamstring muscle flexibility and agility are important components that affect futsal players' performance. The hamstring muscle, located at the back of the thigh, plays a crucial role in movements such as running, kicking, and changing direction, and is one of the muscles most prone to injury, particularly during high-intensity training (1).

Various training methods have been developed to improve flexibility and agility to enhance the effectiveness of players on the field. Active static stretching is a stretching method performed actively by maintaining a certain position to slowly lengthen the muscle and connective tissue, thereby increasing tolerance to stretching and reducing muscle stiffness (2). This exercise has been proven to be effective in increasing short-term flexibility (3). However, its drawbacks include the potential for a decrease in eccentric muscle strength and explosive performance if performed chronically (4).

Eccentric exercise emphasizes muscle contraction during lengthening and has been used to increase structural muscle strength and prevent hamstring injuries. This exercise also has a positive effect on long-term muscle flexibility (5). Research shows that eccentric exercise can improve flexibility and agility, even more than static stretching (1). Nevertheless, this exercise has disadvantages, such as the risk of delayed onset muscle soreness (DOMS) and micro-injuries if not performed with warm-ups or gradual progression (2).

Based on preliminary research conducted at the Bali Bulldogs Football Club, which consists of young adult players, it was found that 10 out of 22 futsal players experienced hamstring muscle shortening and decreased agility. Given the advantages and disadvantages of each intervention, a direct comparison of the relative effectiveness of these two interventions in the specific condition of futsal players is needed, as research is still limited, which is the basis for this study. The general objective of this study was to determine the difference in the effects of active static stretching and eccentric exercise on increasing hamstring muscle flexibility and agility in futsal players.

2. METHOD

The instruments used in this study included a goniometer to measure hamstring flexibility using the Active Knee Extension Test (AKET) and the Illinois Agility Test using cones and a stopwatch to measure agility. The research procedure began with an explanation of the study, completion of questionnaires, and measurement of BMI. Next, a pre-test was conducted to measure the hamstring flexibility and agility. Both groups were then given their respective exercise interventions three times a week for six weeks. At the end of the intervention, a post-test was conducted using the same instruments. Data were analyzed using SPSS statistical software version 22. Data normality was tested using the Shapir Wilk test. Data were analyzed using the paired simple t-test to determine differences within groups and the independent t-test to determine differences between groups.

This study used a quasi-experimental design with a pre and post-test only design. This study was divided into two groups: the first treatment group was given active static stretching, and the second treatment group was given eccentric exercise. The sampling technique was Purposive random sampling was used. Before the patients were recruited, this study was approved by the Faculty of Medicine, Udayana University/Sanglah General Hospital, Denpasar, with an ethical approval number 1902/UN14.2.2. VII.14/LT/2025. An explanation of the study'sprocedures and benefits was provided to all respondents before the study began.

This study was conducted at the Bali Bulldogs Football Club with a population of Bali Bulldogs Football Club futsal players who experienced hamstring muscle shortening and decreased agility. Samples were selected based on the following inclusion criteria: age 18-25 years old, male sex, active knee extension angle > 20º °(poor flexibility), Illinois agility test score > 17 seconds (below average), body mass index (BMI) in the normal category (18.5 – 22.9 kg/m²), normal physical activity (≥ 600 MET-min/week), and willingness to participate in the study by signing an informed consent. Participants with a history of surgery or musculoskeletal injury, cardiovascular or neurological disorders, or those receiving other exercises outside of the designed program during the study period were excluded. Subjects were declared as drop outs if they attended less than 85% of the futsal training sessions or left the club during the intervention.

A purposive sampling method was used with samples meeting the inclusion and exclusion criteria, and 22 subjects were obtained. The samples were randomly divided into two groups, each consisting of 11 subjects. The first treatment group received active static stretching and the second received eccentric exercise.

The researcher provided an explanation about the benefits, purpose, how the research would be conducted, and the importance of the study so that the subjects understood and were willing to become voluntary samples. Participants filled out a self-identity questionnaire, BMI measurement, Informed Consent, and GPAQ. Next, the researcher conducted a pre-test by measuring hamstring flexibility with the Active Knee Extension Test (AKET) and measuring agility with the Illinois agility test. The subjects were divided into 2 groups, with the researchers and assessors not knowing which group was the first and which was the second. The first treatment group was given an intervention in the form of active stretching exercise in a standing position, then asked to place their leg on a knee-high table, with the ankle in dorsiflexion and the knee straight. After that, they were instructed to hold their waist in a neutral position and bend their body until a slight pain was felt in the hamstring. The subjects were asked to hold this position for 30 seconds. The second treatment group was given an intervention in the form of eccentric exercise in a supine position, then the subjects wrapped their heel with a thera-band and pulled the thera-band with both hands. In the starting position, the knee joint was in full extension. Using the thera-band, the hip was flexed while resisting by eccentrically contracting the hamstring throughout the full range of the hip joint. The subject was asked to apply enough force to feel the hamstring contraction. The subject was told to apply enough force while resisting the eccentric force of the hamstring and hold for about 5 seconds to complete the entire range of hip flexion. This was done with a gentle pull. Without rest, with six repetitions, the total exercise was 30 seconds. Both exercises were done 3 times a week for 6 weeks. After that, a post-test was conducted to assess changes in increased hamstring muscle flexibility and agility. The obtained data were analyzed using SPSS software version 22.

This study assessed changes in hamstring muscle flexibility using the ankle knee extension test (AKET) and changes in agility using the Illinois agility test.

Research data analysis was performed using the statistical software SPSS version 22. A descriptive test was used to describe the characteristics of the research sample based on the distribution of age, body mass index (BMI), global physical activity questionnaire (GPAQ), pre-test ankle knee extension test, and pre-test Illinois agility test. Data normality for the pre-test, post-test, and difference values of the ankle knee extension test and Illinois agility test before and after the intervention were analyzed using the Shapiro Wilk test (p>0.05, indicating a normal distribution). Homogeneity testing to determine data variation was performed using the Levene test (p>0.05 indicating homogeneous data). Hypothesis testing used parametric statistical tests, namely the paired sample t-test to analyze the difference in the effect of active static stretching and eccentric exercise before and after the intervention in each group, and the independent sample t-test to compare the results between groups after the intervention.Differences were considered statistically significant at p<0.05.

3. RESULTS AND DISCUSSION

Result

a. Characteristics of the research subjects

The characteristics of the research subjects included the distribution of age, body mass index (BMI), global physical activity questionnaire (GPAQ), pre-test ankle knee extension test, and pre-test Illinois agility test, which can be seen in Table 1.

Table 1
Characteristics of Research Subjects Between Groups

Sample Characteristics	Treatment Group I	Treatment Group II	*P*
	N=11	N=11	
	Mean ± SD	Mean ± SD	
Age (years)	21.91 ± 2.119	21.45 ± 2.207	0.628
Body Mass Index (kg/m^2)	21.705 ± 1.2025	21.718 ± 1.0313	0.979
GPAQ	6.02364 ± 2.226456	6.91455 ± 2.773735	0.416
Pre-test Ankle Knee Extension Test (degrees)	29.09 ± 5.0071	31.582 ± 5.0543	0.298
Pre-test Illinois Agility Test (seconds)	18.227 ± 0.5934	18.945 ± 1.1877	0.088

As shown in Table 1, a comparative analysis of age, body mass index, pre-test ankle/kneeextension, and pre-test Illinois agility test showed no significant differences (p> 0.05). Therefore, the sample characteristics of the two groups were comparable.

b. Normality and homogeneity test

Table 2
Normality and Homogeneity Test Between Groups

Variable	Time	*Shapiro Wilk Test* Treatment Group I	*Shapiro Wilk Test* Treatment Group II	*Levene's Test* (homogeneity)
		p-value	p-value	
Ankle Knee Extension Test	*Pre-test*	0.897	0.257	0.738
	Post-test	0.912	0.132	0.962
	Difference	0.846	0.230	0.000
Illinois Agility Test	*Pre-test*	0.642	0.576	0.036
	Post-test	0.578	0.927	0.274
	Difference	0.049	0.008	0.067

Based on Table 2, the results of the normality test (using the *Shapiro-Wilk Test*) show that the p-value in the *ankle knee extension* (*pre-test, post-test*, and difference) for the first and second treatment groups has a p-value > 0.05, which means the data is normally distributed. The p value of *the Illinois agility test* (*pre-test* and *post-test*) for the first and second treatment groups was > 0.05, which means that the data were normally distributed. However, the difference between groups had a p-value <0.05, which means that the data were not normally distributed. The results of the homogeneity test (*Levene's Test*) for both groups showed that the data variance was homogeneous (p> 0.05), except for the difference in *ankle knee extension* which had a p-value of 0.000 (p < 0.05), indicating that the data variance was not homogeneous. Meanwhile, in the *pre- test* data of *the illinois agility test*, the p value was 0.036 (p< 0.05), indicating that the data variance was not homogeneous.

c. Test of Difference in Hamstring Muscle Flexibility Before and after active static stretching in futsal players

Table 3
Test of Difference in Hamstring Muscle Flexibility with Active Statistic Stretching

	Hamstring Muscle Flexibility (degrees) (Mean ± SD)	P value
Before Treatment	29.291 ± 5.0071	0.000
After Treatment	28.809 ± 5.1034	

Based on Table 3, it can be concluded that there is a significant difference in the results of the difference test before and after, with a p-value of 0.000 (p-value <0.05).

d. Test of difference in hamstring muscle flexibility before and after eccentric exercise in futsal players

Table 4
Test of Difference in Hamstring Flexibility with Eccentric Exercise

	Hamstring Muscle Flexibility (degrees) (Mean ± SD)	P value
Before Treatment	31.582 ± 5.0543	0.000
After Treatment	28.173 ± 4.8121	

Based on Table 4, there was a significant difference in the results of the difference test before and after the intervention (p= 0.000 p<0.05).

e. Test of difference in agility before and after active static stretching in futsal players

Table 5
Test of Difference in Agility with Active Static Stretching

	Agility (second) (Mean ± SD)	P value
Before Treatment	18.227 ± 0.5934	0.000
After Treatment	17.945 ± 0.6362	

Based on Table 5, it is concluded that there is a significant difference in the results of the difference test before and after, with a p-value of 0.003 (p-value <0.05).

f. Test of difference in agility before and after eccentric exercise in futsal players

Table 6
Test of Difference in Agility with Eccentric Exercise

	Agility (seconds) (Mean ± SD)	P value
Before Treatment	18.945 ± 1.1877	0.000
After Treatment	17.818 ± 0.9888	

Based on Table 6, there was a significant difference in the results of the t-test before and after with a p-value of 0.003 (p-value <0.05).

g. Differential test of the effect of *active static stretching* and *eccentric exercise* groups on increasing *hamstring* muscle flexibility in futsal players.

Table 7
Test of Difference in Hamstring Muscle Flexibility Between Groups

Hamstring Muscle Flexibility (*Ankle Knee Extension Test*)			
	Treatment Group I (degrees) (Mean ± SD)	Treatment Group II (degrees) (Mean ± SD)	*p-value*
Difference	- 0.482 ± 0.1722	- 3.409 ± 1.0521	0.000

The difference test results between the *active static stretching* and *eccentric exercise* groups in Table 7 show a *p-value* <0.05, indicating a statistically significant difference in increasing *hamstring* muscle flexibility between the two groups.

h. Differential test of the effect of *active static stretching* and *eccentric exercise* groups on agility in futsal players.

Table 8
Test of Difference in Agility Between Groups

Agility (*Illinois Agility Test*)			
	Treatment Group I (detik) (Mean ± SD)	Treatment Group II (second) (Mean ± SD)	Sig
Difference	-0.482 ± 0.1722	-3.409 ± 1.0521	0.000

The difference test results between the *active static stretching* and *eccentric exercise* groups in Table 8 show a *p-value* <0.05, indicating a statistically significant difference in increasing *hamstring* muscle agility between the two groups.

Discussion

Characteristics of research subjects

The results of this study (Table 1) showed that *the mean* age of the participants in the first and second treatment groups was not significantly different, indicating that the data were normally distributed with an average age of 22 years. Based on age classification according to the Ministry of Health, the average age of the participants in this study was included in the late adolescent category (6). The research subjects represented the target population, namely all Bali Bulldog Football Club futsal players, with a total of 22 subjects. The age of 18-25 years is often the age of peak athletic performance, where the response to training tends to be optimal. Several studies have shown that futsal player in this age range tend to have a fairly high risk of *hamstring* injury if their muscle flexibility is less than optimal (7).

Based on Table 1, the BMI of the research subjects between groups had the same characteristics (p> 0.05), where the range of BMI in futsal players in this study was normal, in accordance with the inclusion criteria expected by researchers with a frequency of 22 subjects. A normal BMI (18.5-24.9 kg/m^2) indicates a balanced body composition between body weight and height. Futsal players with normal BMI tend to have more optimal physical performance than those who are *underweight* or *overweight* (8). Studies testing the effectiveness of stretching on *hamstring* flexibility in futsal players often include samples with normal BMI as the majority characteristic, suggesting that normal body condition is a good basis for improving flexibility (7). A normal BMI is positively correlated with better agility in futsal athletes. An ideal BMI allows for more efficient movement and responsiveness to changes in direction (9).

In the GPAQ characteristics in Table 1, there was no significant difference in GPAQ scores between the first and second treatment groups (p > 0.05), although the second treatment group had a slightly higher mean GPAQ score. Futsal players with a high level of physical activity based on the GPAQ are likely to have a better physical foundation, which may affect their response to exercise interventions. (Kalman *et al.*, 2014). This is supported by research on the effectiveness of stretching on *hamstring* flexibility in futsal players, implicitly supporting that players with good *physical fitness* including high levels of physical activity, will have better flexibility (10). Research examining the relationship between physical activity and agility in futsal athletes often implicitly supports the notion that higher levels of physical activity correlate with better agility (9).

The mean *pre-test* value of *hamstring* muscle flexibility in Table 1 measured using AKET shows 29.291 degrees in Treatment Group I and 31.582 in Treatment Group II, which means that the flexibility value in both groups is in the category of less flexibility (> 20 degrees). There was no significant difference in the results of the *pre-test ankle knee extension test* between the first and second treatment groups (p> 0.05). The mean value of the agility *pre-test* in Table 1 as measured using the *Illinois* agility *test* shows 18.227 seconds in Treatment Group I and 18.945 seconds in the second treatment group, which means that the agility value in both groups is in the below-average category (> 17 seconds). In the *pre-test* value of the *Illinois agility test*, there was no significant difference in the *pre-*

test results of the *Illinois agility test* between the first and second treatment groups (p> 0.05). This shows that the initial characteristics of both groups had relatively homogeneous or comparable values.

***Active static stretching* intervention on improving *hamstring* muscle flexibility**

Based on this study, the *pre* and *post* results of the two treatment groups showed a p value of 0.05, this indicates that there is a significant difference in *hamstring* muscle flexibility. *Eccentric exercise* is a muscle contraction in which the muscle extends under load. The addition of sarcomeres in series, namely, one of the main mechanisms of *eccentric exercise* in increasing flexibility is through the addition of sarcomeres (muscle contractile units) in series (13). Muscle is repeatedly forced to lengthen under high tension, the body adapts by adding new sarcomeres, which permanently increases the resting length of the muscle. This is in contrast to static stretching which is more of a temporary change in muscle length (14). *Stretch tolerance* in *eccentric exercise* increases a person's ability to tolerate more extreme stretched positions. This means the pain threshold when stretching becomes higher, allowing the individual to stretch the muscle further before feeling discomfort. Eccentric *exercise* can affect the stiffness of the muscle-tendon unit, by reducing stiffness, this unit becomes more pliable and able to extend better, *eccentric exercise* also affects the viscoelastic properties of the muscle (15). By applying tension to the muscle as it extends, eccentric exercise can trigger restructuring of collagen and elastin in the connective tissue, which improves the ability of the muscle to stretch and return to its original shape (16). One of the main mechanisms of *eccentric exercise* in improving *hamstring* flexibility is the increase in muscle fascicle length, especially at the *biceps femoris long head*. Longer fascicles allow the muscle to extend further before reaching its tension limit, effectively increasing the flexibility of the muscle structurally. This change in muscle architecture is very important as it directly relates to the capacity of the muscle to stretch (17).

***Active static stretching* intervention on agility**

Based on this study, the *pre* and *post* results of the two treatment groups showed a p value of < 0.05, this shows that there is a significant difference in agility. *Active static stretching* involves stretching a muscle to a certain limit and holding it for a certain period. Futsal players need optimal flexibility of the hamstrings and other leg muscles to perform *sprints*, sharp turns, and *lunges* (14). *Active static stretching* effectively increases muscle ROM and flexibility, allowing players to perform more efficient and powerful movements without the hindrance of stiff muscles. For example, *stride length* when running or depth when changing direction can be increased if the muscles are more flexible. Less flexible muscles can act as mechanical brakes, limiting the movement speed and efficiency. By increasing muscle length and reducing stiffness through *active static stretching*, faster and more responsive *movement* (18). This indirectly supports agility, as the body can move through different positions more easily. Good flexibility resulting from *active static stretching* helps reduce the risk of *hamstring* and other musculoskeletal injuries. Injury-free players can train and compete consistently, which ultimately improves agility levels through continued training adaptations (19).

***Eccentric Exercise* Intervention on Agility**

Based on this study, the *pre* and *post* results of the two groups showed a p-value of < 0.05, indiacting a significant difference in agility. According to research by (20), *eccentric exercise* involves muscle contraction when extending under load, which is a very relevant component and often has a greater effect on agility. Agility is not only about acceleration but also about the ability to brake or decelerate quickly and in a controlled manner. This deceleration movement relies heavily on the eccentric strength of the *hamstring*, *quadriceps* and calf muscles. For example, when a player runs fast and suddenly stops to change direction, the *hamstring* muscles work eccentrically to resist and control the movement of the knee and pelvis. The ability to change direction quickly and efficiently is the essence of agility (14).

Eccentric training helps increase muscle strength and endurance when absorbing and generating force in unstable positions, such as *pivoting* or *cutting*. Eccentrically strong muscles allow for a faster and more explosive transition from the deceleration to acceleration phase during a change in direction (21). *Eccentric exercise* also triggers neuromuscular adaptations that improve muscle coordination and control at high speeds and extreme ranges of motion. This means that the nervous system and muscles can work together more efficiently to respond to the demands of rapid changes in direction, thereby improving reaction time and movement efficiency (18). *Eccentric exercise*, particularly in the *hamstring*, can increase muscle fascicle length. Longer fascicles are associated with the ability of the muscle to generate greater force and have an increased capacity to absorb loads. This contributes to injury protection and allows the muscle to function optimally during complex agility movements (17).

Intervention of *Active Static Stretching* and *Eccentric Exercise* to Increase *Hamstring* Muscle Flexibility in Futsal Players

Based on the results of the difference test between the *active static stretching* and *eccentric exercise* groups in Table 7, the difference results show a *p-value* <0.05, it can be concluded that there is a statistically significant difference in increasing *hamstring* muscle flexibility between Treatment Groups I and II. The combination of interventions in Treatment Group I, namely *active static stretching* and Treatment Group II, namely *eccentric exercise* can increase *hamstring* muscle flexibility in futsal players. The results of the *mean* difference test on the treatment between Treatment Groups I and II on *hamstring* muscle flexibility showed that the mean value of Group I *mean* value -5.727 and that of Group II *mean* value -10.145. This shows that *eccentric exercise* is better than *active static stretching* for increasing *hamstring* muscle flexibility in futsal players.

Mechanically, the increase in muscle flexibility due to *active static stretching* can be explained through two mechanisms: muscles and connective tissues, such as tendons and ligaments, have viscoelastic properties, which allow them to stretch and return to their original shape. When *stretching* is performed regularly, the viscosity of the connective tissue decreases, and the resistance to stretching decreases. In addition, its elasticity may also increase, which collectively allows the muscle to stretch further (22). These changes are short-term and are the immediate physiological response of the muscles to stretching. Second, through stretch tolerance, *active static stretching* can increase an individual's tolerance to stretching. This occurs through the desensitization of the *golgi tendon organ* (GTO), a nerve receptor located at the border of the muscle and tendon. The GTO functions as a "brake" that sends signals to the brain to stop muscle contraction when excessive tension occurs as a protective mechanism. With repeated *stretching*, the GTO becomes less sensitive, and its threshold of stimulation increases. As a result, one can hold the stretching position longer and deeper without feeling any discomfort, ultimately improving functional flexibility (23).

Eccentric exercise involves muscle contraction as the muscle lengthens, triggering a unique cellular adaptation response. This promotes the serial addition of muscle contractile units, called sarcomeres (*sarcomereogenesis*). This addition of sarcomeres permanently lengthens the muscle fasciculus, which is the structural basis for the long-term improvement in flexibility. This mechanism is not observed during passive *stretching* (23). *Eccentric exercise* also increases an individual's tolerance to stretching by reducing the sensitivity of the *golgi tendon organ* (GTO). However, this increased tolerance is amplified by the structural changes that occur, allowing the subjects to achieve a greater range of motion with less discomfort (19). One of the main advantages of *eccentric exercise* is its ability to increase muscle strength when the muscles are in an elongated position. This adaptation not only increases flexibility but also strengthens muscles in positions prone to injury, which is highly relevant for injury prevention, particularly in dynamic sports such as futsal (24).

Active static stretching provides a more generalized and immediate stretch to the muscle-tendon unit, whereas *eccentric exercise* produces long-term structural changes in muscle fascicle length and stretch tolerance (19). This combination addresses flexibility from multiple perspective: short-term (stretch adaptation) and long-term (changes in muscle architecture). Improved *hamstring* flexibility through these two methods significantly reduces the risk of *hamstring* strain injury, which is a common injury in sports with explosive movements, such as futsal (11). A longer, more flexible muscle is less likely to be pulled when *sprinting*, kicking, or changing direction quickly.

Futsal players with more flexible *hamstrings* can perform movements with a greater range of motion and higher efficiency. This translates to longer *stride lengths* when running, better range when kicking, and a greater ability to change direction smoothly, all of which contribute to improved performance on the field (14). *Eccentric exercise* compares favorably with *Active static stretching* in improving hamstring muscle flexibility, supporting athletic performance, and minimizing the risk of injury (19).

***Active Static Stretching* and *Eccentric Exercise* Intervention on Improving Agility in Futsal Players**

Based on the results of the difference test between the *active static stretching* and *eccentric exercise* groups in Table 8, the difference results show a *p-value* <0.05, it can be concluded that there is a statistically significant difference in increasing agility between Treatment Groups I and II. The *mean* result of the difference test on the treatment between Treatment Groups I and II on agility, namely in Group I *mean* value -1.191 and Treatment Group II *mean* value -2.22. This shows that *eccentric exercise* is better than *active static stretching* for increasing agility in futsal players.

The improvement in agility as a result of *stretching* can be explained by the close relationship between flexibility and agility. Agility is defined as the ability to change direction and speed quickly and efficiently. It relies heavily on the optimal joint range of motion and the ability of muscles to work unimpeded. When hamstring muscle flexibility is increased, muscle stiffness is reduced, allowing for freer and more explosive leg movements (25).

Active static stretching builds the foundation of flexibility needed for muscles to move freely and unhindered, whereas *eccentric exercise* builds the strength needed to control and execute fast and dynamic agility movements (12). Optimal flexibility allows the body to reach the correct position quickly, and eccentric strength ensures that the body can control and transition from that position efficiently. Better flexibility from static stretching can reduce the risk of injury caused by motion limitation, whereas eccentric strength directly protects muscles from strain injury during deceleration or rapid direction changes (11). By reducing the incidence of injuries, players can maintain consistency in training and competition, which is essential for long-term agility development. This combination results in *hamstring* muscles that are not only strong but also flexible and responsive. Players can change direction, accelerate, and decelerate with more speed and less effort because their muscles are more efficient at absorbing and generating force (19).

In the results of this study, the agility variable showed significant differences between the treatment groups. Agility is the ability to change direction and speed effectively, which relies heavily on a combination of strength, speed, and neuromuscular control (26). *Eccentric* exercise improves neuromuscular signaling and joint stability in the lower extremities. Increased hamstring muscle strength over a greater range of motion allows better control of the knee and hip joints during agility movements. This reduces the risk of injury and allows athletes to perform movements more confidently and efficiently (19). *Eccentric exercise* is known to cause the addition of sarcomeres (muscle contractile units) in series, structurally lengthening the muscle. These changes permanently increase the flexibility and range of motion. With more flexible and stronger muscles over a wide range of motion, agility performance improves as athletes can move with minimal resistance (27).

Eccentric exercise increases the ability of muscles to absorb and generate force while extending, which is an important component of *cutting* and *deceleration* movements that are the basis of agility. According to Chaabene *et al.*, (2020), in their systematic review of the effects of agility training on soccer players, they emphasized the importance of exercises involving changes in direction and speed, which often involve strong eccentric contractions. Increased eccentric strength in the hamstring muscles, which serve as the main accelerators and decelerators of the legs, can directly increase efficiency and speed in changing direction (28). This study concluded that *eccentric exercise* is more effective than active static stretching in improving the physical components that contribute to overall agility in futsal players, compared to *active static stretching*.

4. CONCLUSION

Eccentric exercise is more effective in improving these three parameters than active static stretching. Further research should generalize a wider sample or population, and the results obtained should represent various groups with different characteristics and increase the applicability of the findings to a more diverse context**.** In addition, a control group is expected to be provided so that the pure effect of the intervention can be distinguished from the influence of external factors or natural changes.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. dr. Indira Vidiari Juhanna, M.Fis, and Dr. Syahmirza Indra Lesmana, SKM, S.Ft, Mor, for their guidance and support throughout this research. The authors acknowledge Udayana University and the Faculty of Medicine for the facilities and support provided, as well as the Bali Bulldogs Football Club and all research participants.

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